U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN No. 24.
B. T. GALLOWAY, Chief of Bureau.



# THE MANUFACTURE AND PRESERVATION OF UNFERMENTED GRAPE MUST.

BY

GEORGE C. HUSMANN,
EXPERT IN CHARGE OF VITICULTURAL INVESTIGATIONS,
POMOLOGICAL INVESTIGATIONS.

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1902.

## BUREAU OF PLANT INDUSTRY.

B. T. Galloway, *Chief of Bureau.*

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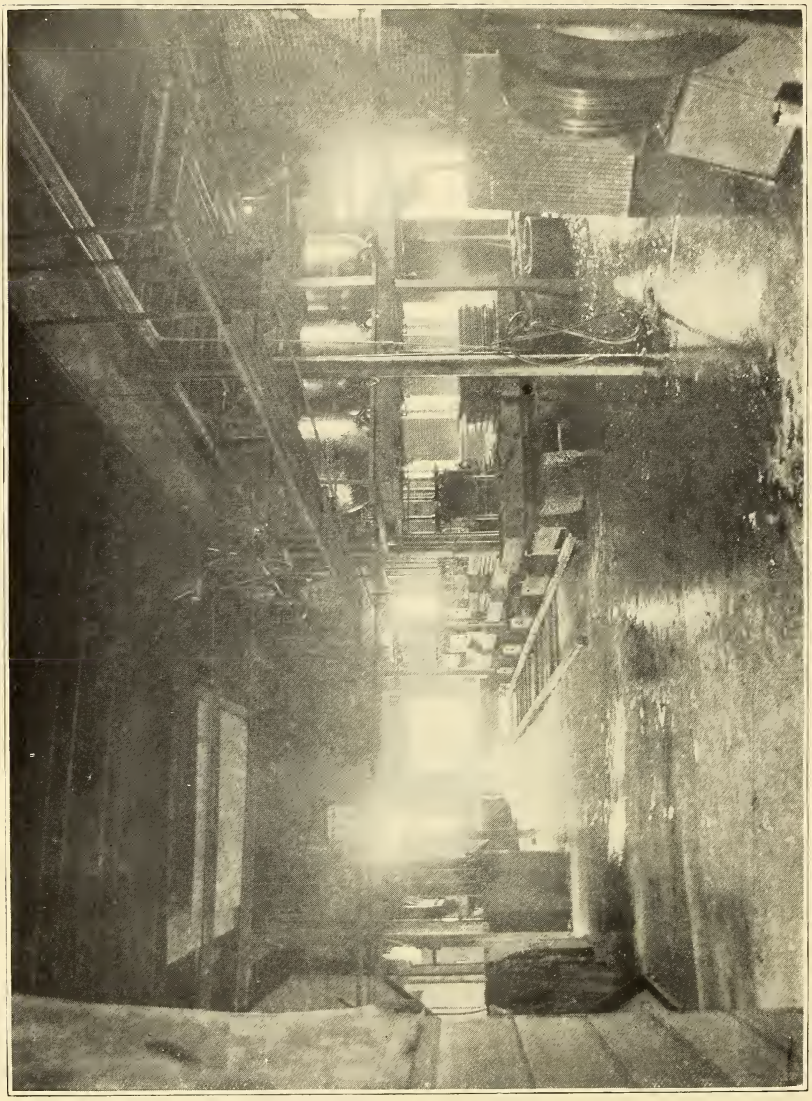

PRESSES AND KETTLES USED IN CHAUTAUQUA GRAPE DISTRICT.

U. S. DEPARTMENT OF AGRICULTURE.

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# LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
*Washington, D. C., July 7, 1902.*

Sir: I have the honor to transmit herewith a paper entitled "The Manufacture and Preservation of Unfermented Grape Must," and respectfully recommend that it be published as Bulletin No. 24 of the Bureau series. The paper was prepared by Mr. George C. Husmann, Expert in Charge of Viticultural Investigations, and was submitted by the Pomologist.

Respectfully,

B. T. Galloway,
*Chief of Bureau.*

Hon. James Wilson,
*Secretary of Agriculture.*

# PREFACE.

This bulletin gives the results of recent investigations undertaken by Mr. George C. Husmann, Expert in Charge of Viticultural Investigations, of this office. The manufacture and preservation of unfermented grape must is a subject that is attracting much attention at present and is of vital interest to both manufacturers and consumers.

Mr. Husmann has made a careful investigation of the industry in both its economical and commercial aspects, and the bulletin is designed to aid both manufacturer and consumer in preparing and utilizing a product of the grape that is of most important economic value.

G. B. Brackett,
*Pomologist.*

Office of the Pomologist,
*Washington, D. C., June 24, 1902.*

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# THE MANUFACTURE AND PRESERVATION OF UNFERMENTED GRAPE MUST.

## INTRODUCTION.

The use of unfermented grape juice is of very ancient origin, being undoubtedly as old as the art of wine making. The industry of manufacturing unfermented grape must on an extensive scale for a general market is, however, as yet in its infancy, as is exemplified by the diversity of the apparatus used in the various factories. Each manufacturer seems to have had a different conception and to have constructed his machinery according to his own ideas.

It is the purpose of this publication to describe the most economical and successful methods of manufacturing must and to discuss its uses and effects on the system, together with the outlook for the commercial success of the industry.

## HISTORICAL NOTES.

Galienus, the Greek physician and writer, says (A. D. 131):

> A good many Asiatic wines were stored in bottles, which were hung in the corner of the fireplaces, where, by evaporation, they became old and dry. This process was called fumarium.

The Greeks had two kinds of wine—the protoplon, or first juice of the grape before pressing, and the denterion, or pressed juice. The Romans called them vinum primarium and vinum secondarium. Some of them drank the juice before fermentation had started, and called it mustum; after the must had been through a heating process (called reduction nowadays), they called it frutum; and when after long heating it had been reduced to one-half or one-third its original volume, they called it sapa. This was used by the Romans on their bread, and was the equivalent of what we now call sirup.

In Europe physicians often send their patients to the wine-growing districts during vintage time to take daily rations of unfermented must as it comes from the crusher. This, however, restricts its use to only one season of the year and to the immediate vicinity of wine districts or to individuals strong enough to undertake a journey.

Of late years extended efforts have been made to keep the must unfermented and put it up in such shape that it can be used anywhere and at all times of the year.

Until recently the use of must was almost exclusively restricted to medicinal purposes. Unrestricted use has been delayed on account of a lack of special knowledge underlying the principles of the process of manufacture and of skill in their application, resulting in many failures, thus making the production of a good article uncertain and very expensive, and inducing some unscrupulous persons to use injurious preservatives to cheapen the cost of manufacture. It is well known that pure must is healthful and nutritious, but with the addition of chemical preservatives it becomes injurious in proportion to the amount and kind of preservative used.

## COMPOSITION OF THE GRAPE.

The grape contains 15 to 35 per cent of sugar (Balling's scale), about 2 to 3 per cent of nitrogenous substances, and some tartaric and malic acids. The skin contains tannin, cream of tartar, and coloring matter. The seeds contain tannin, amylaceous matters, and fat. The stems contain tannin, divers acids, and mucilaginous matter. The comparative composition of the different parts of the fruit determines the value of must made from any grape.

## CAUSES OF FERMENTATION.

It is well known that grapes and other fruits when ripe have the invisible spores of various fungi, yeast (ferments), and bacteria adhering to them. When dry these are inert, but after the grapes are crushed and they are surrounded by the must they become active and begin to multiply. If the must is warm, the changes take place rapidly; if, on the other hand, it is cool, the change is slower. But in either case, if left alone, the organisms increase until the must ferments. The most favorable temperature for fermentation is between 65° and 88° F. Cold checks, but does not kill, the ferment. This fermentation, now commonly called the elliptic yeast, changes the sugar in the grape to alcohol and carbonic acid gas, and is the leading factor in converting must into wine; hence it will be readily seen that to keep unfermented must sweet, fermentation must be prevented, and to be salable the product must be clear, bright, and attractive.

## METHODS OF PREVENTING FERMENTATION

Fermentation can be prevented in either of two ways:

(1) By chemical methods, which consist in the addition of germ poisons or antiseptics, which either kill the germs or prevent their growth. Of these, the principal ones used are salicylic, sulphurous, boracic, and benzoic acids, formalin, fluorides, and saccharin. As these sub-

stances are generally regarded as adulterants and injurious, they should not be used.

(2) Mechanical means are sometimes employed. The germs are either removed by some mechanical means, such as a filtering or a centrifugal apparatus, or they are destroyed by heat, electricity, etc. Of these, heat has so far been the most practical.

When a liquid is heated to a sufficiently high temperature all organisms in it are killed. The degree of heat required, however, differs not only with the particular variety of organisms, but also with the liquid in which they are held. Time is also a factor. An organism may not be killed if heated to a high temperature and quickly cooled. If, however, the temperature is kept at the same high degree for some time, it will be killed. It must also be borne in mind that fungi, including yeasts, exist in the growing and the resting states, the latter being much more resistant than the former. A characteristic of the fungi and their spores is their great resistance to heat when dry. In this state they can be heated to 212° F. without being killed. The spores of the common mold are even more resistant. This should be well considered in sterilizing the bottles and corks, which should be steamed to 240° F. for at least fifteen minutes.

Practical tests so far made indicate that must can be safely sterilized at from 165° to 176° F. At this temperature the flavor is hardly changed, while at a temperature much above 200° F. it is. This is an important point, as the success of an enterprise of this character depends entirely upon the flavor and quality of the product.

Such a vast difference exists in the methods pursued in California and in the Eastern States that a description of each is here given.

## PROCESS USED IN CALIFORNIA.

This method, as described in Bulletin No. 130 of the California Experiment Station, is in substance as follows: Only clean and perfectly sound grapes, preferably those having a high natural acidity, picked and handled when cool, should be used. This fruit should not be too ripe or the must will be too sweet and be difficult to clarify. The grapes are pressed immediately and the juice is run into clean, sterilized puncheons or other receptacles. If the must is 59° F. or under, it may be left to settle for twenty-four hours or more. This rids the juice of most of the floating solid matter and facilitates subsequent filtering. It is then passed through a continuous pasteurizer (see fig. 1) and heated to 175° F., and should come out not warmer than 77° F. when it is run directly by means of a block-tin pipe into fresh vessels. For this purpose sterilized puncheons or other casks may be used, although casks or vats of metal, lined with enamel, would be better.

The greatest care must be taken to avoid contamination of the must

as it flows from the pasteurizer. The ends of the block-tin pipe should be plunged into boiling water in changing from one package to another, and should not touch the hands or any exposed surface. The package should be closed with a sterilized bung as soon as full. After the must has settled some days, or even weeks, it is ready for filtering. This filtration is best accomplished by means of a filter so constructed that the must passes upward through the filtering medium under pressure. Such a filter is seen in fig. 2. This filter consists essentially of two shallow bowls clamped together, mouth to mouth, with the filtering medium between them. The unfiltered must enters the lower bowl through the pipe on the right of the figure, passes through the filtering medium into the upper bowl, and makes its exit, when clear, through the faucet a little to the left of the middle

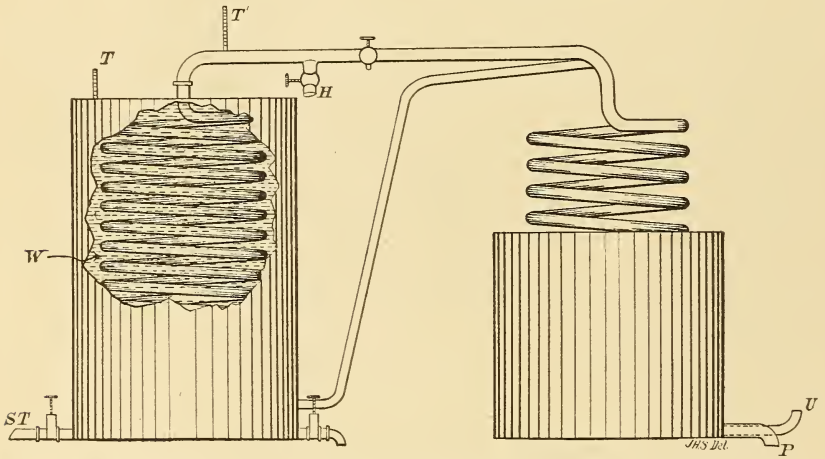


FIG. 1.—Continuous Pasteurizer: *ST*, Steam pipe. *H*, Outlet for hot pasteurized must. *U*, Inlet for unpasteurized must. *W*, Water bath. *P*, Outlet for cooled pasteurized must. *TT'*, Thermometers.

of the figure. The small faucet at the bottom of the lower bowl is for the purpose of cleaning the filter. Occasionally when filtration becomes slow, this faucet is opened for a few minutes. This allows the sediment accumulated at the bottom to escape and at the same time the entering must takes a rotary motion in the lower bowl, thus clearing off the surface of the filtering medium, so that when the clearing faucet is closed filtration proceeds as before. On a large scale a filter press such as is used in large wineries and in beet-sugar factories might be conveniently used.

The must should be bottled as it flows from the filter, corked immediately, and sterilized as soon as possible, preferably within twenty-four hours. On account of recontamination during filtering, a final sterilization must be made after the bottles are corked. This is accomplished by means of a bottle sterilizer.

A simple and efficient form of sterilizer is shown in fig. 3. It consists of a wooden trough, provided with a wooden grating placed about 2 inches from the bottom. The filled bottles are placed in wire baskets which rest upon the grating. The trough should contain enough water to submerge the bottles and be kept at 185° F. by means of a steam coil beneath the grating. It requires fifteen minutes for the must at the bottom to acquire that temperature. For packages of other sizes it is necessary to make a test with a bottle of must in which a thermometer has been placed, in order to determine how long it takes for the entire contents of the bottle to reach the required temperature. Sterilization in bottles should be conducted at a temperature at least 90° F. lower than that reached in the continuous pasteurizer. If the final heating is higher than the first, it may cause a precipitation of solid matter, which will make the must in the bottles cloudy.

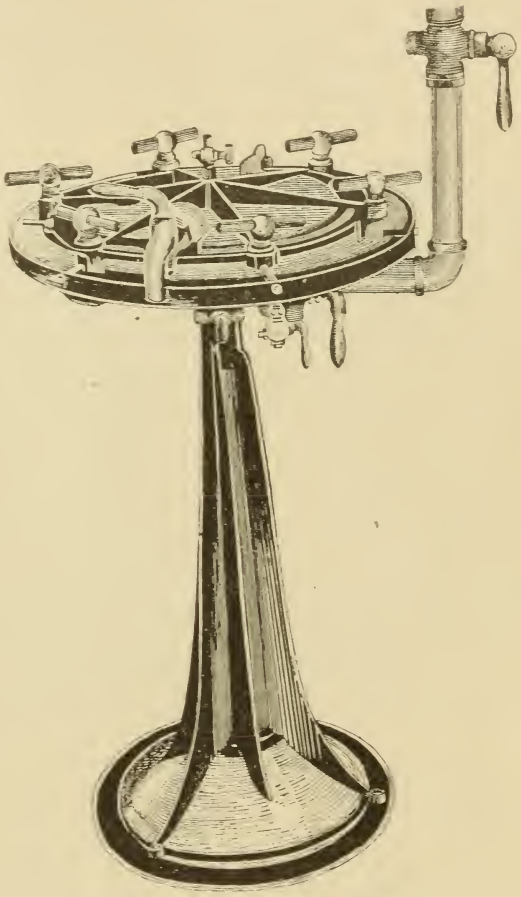

FIG. 2.—Filter for clarifying must.

During the sterilization in bottles the corks are liable to be expelled by the pressure developed. To prevent this they may be tied down with strong twine, but it is a great saving of time and labor to use some such contrivance as illustrated in fig. 3. Must so sterilized will keep unchanged for years, or until the bottles are opened.

No matter how carefully all previous work may be done, there is still danger of mold germs getting into the liquid through the corks, especially if a poor quality of corks be used. This can be prevented by dipping the necks of the bottles into heated paraffin before putting on the caps or by sealing over the corks with sealing wax.

The quality and character of the grape must will vary greatly with

the quality of the grapes used, and a pleasing effect may be had by the blending or mixing of the must of two or more varieties of grapes. The color of the must will always be white or yellowish, with the exception of that from such varieties as the Bouschets, which have a red juice. Red must can be obtained by a modification of the process described. If the must is allowed to pass through the continuous pasteurizer and flow out hot into a vat containing the skins of red grapes, almost any desired depth of color may be obtained, depending on the variety of grapes used and the time during which the hot must is left on the skins. Must thus prepared differs in other respects than color from the white must, various substances, especially tannin,

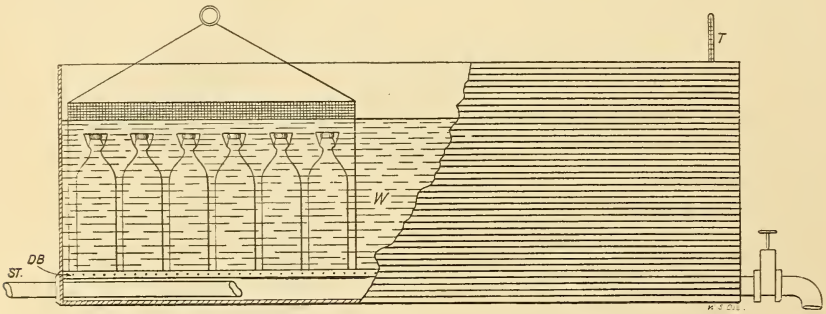


FIG. 3.—Cork clamp and pasteurizer for must in bottles: *DB*, Double bottom. *ST*, Steam pipe. *W* Water bath. *T*, Thermometer. (Bottle shows method of adjusting a cork holder of sheet metal.)

being extracted from the skins, making the composition more like that of red wine, but containing sugar instead of alcohol. In some instances such an article will be preferred for medicinal use.

## METHODS USED IN THE EASTERN STATES.

The methods used in the larger plants of the Eastern States, principally in the Chautauqua district on Lake Erie, are as follows:

The grapes are run through a combined crusher and stemmer in the upper story of the building, passing through wooden chutes to three aluminum kettles directly underneath. (See Frontispiece.) These kettles have double bottoms, so that steam can be used for heating without coming in contact with the contents. They also have in them revolving cylinders which keep the crushed grapes thoroughly stirred while they are being heated to 140° F. This heating and stirring aids in getting more color out of the skins, the relative amount of juice obtained per ton of grapes is larger, and the must has more of the ingredients and taste of red wine, without containing any alcohol. These kettles are filled in rotation, namely: As soon as No. 1 is full, steam is turned on to heat it while No. 2 is being filled. By the time No. 2 is full No. 1 is hot. Steam is then turned on No. 2 while No. 3 is being filled, and No. 1 is emptied and ready to be filled again.

Underneath the kettles are the presses, which are of the hydraulic type. Into these the heated contents of the kettles are emptied and pressed. They are on wheels, and are run backward and forward for filling and emptying in regular rotation. From the presses the juice runs through pipes to aluminum kettles underneath, similar to those in which the crushed grapes are heated, except that they contain no revolving cylinders. (See fig. 4.) In these kettles the juice is heated to 165° F., skimmed, and run through a pasteurizer underneath at a temperature no lower than 175° F. and no higher than 200° F. From the pasteurizer the must is filled directly into freshly sterilized 5-gallon carboys, securely corked, and stored in the vaults until the juice has settled and cleared, after which the clear juice is carefully siphoned

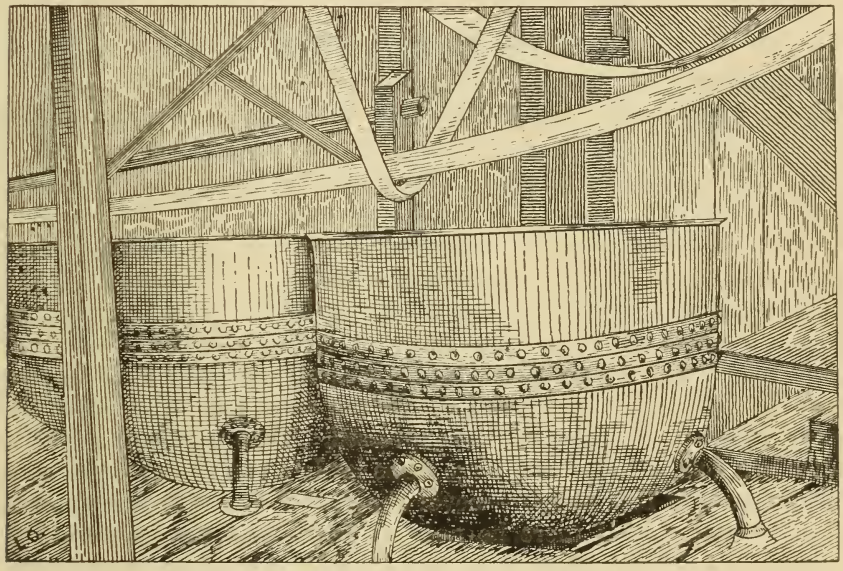

FIG. 4.—Aluminum kettles for heating crushed grapes.

off, filtered, filled into bottles, and securely corked, undergoing a final pasteurizing in the bottles, as explained in describing the California method.

By the method just described a dark-colored liquid is made, usually called grape juice. Nine-tenths of the eastern musts placed on the market are of this kind. Should it be desired to make a lighter-colored smooth article, the process should be modified by omitting the heating and stirring before pressing, the crushed grapes being pressed at once.

Attention should be called to the fact that the leading defects so far found with unfermented juice placed on the market are that much of it is not clear, a condition which very much detracts from its otherwise attractive appearance, and is due to two causes already alluded

to—either the final sterilization in bottles has been at a higher temperature than the preceding one, or the juice has been improperly filtered or has not been filtered at all.

In other cases the juices have been sterilized at such high temperature that they have a disagreeable, scorched taste. It should be remembered that when an attempt is made to sterilize at a temperature above 195° F., one is treading on dangerous ground. Another serious mistake has been made in placing grape juice on the market in too large bottles, so that much of it becomes spoiled before it is used.

Grape must properly made and bottled will keep indefinitely if it is not exposed to the atmosphere or mold germs; but when a bottle is once opened it should, like canned goods, be used as soon as possible to keep it from spoiling.

## HOME MANUFACTURE.

Friends who are fortunate enough to have a small patch, perhaps only an arbor, of grape vines often tell us: "We have so many grapes we do not know what to do with them." The surplus may be used to make unfermented grape juice. The following recipe will enable anyone to make it:

Use only clean, sound, well-ripened grapes. If an ordinary cider mill is at hand, it may be used for crushing and pressing, or the grapes may be crushed and pressed with the hands. If a light-colored juice is desired, put the crushed grapes in a cleanly washed cloth flour sack and tie up. Then either hang up securely and twist it, or let two persons take hold, one on each end of the sack, and twist, when the greater part of the juice will be expressed. Then gradually heat the juice in a double boiler or a large stone jar in a pan of hot water at a temperature of 180° to 200°—never above 200° F. It is best to use a thermometer, but if there be none at hand, heat the juice until it steams, but do not allow it to boil; put it in a glass or enameled vessel to settle for twenty-four hours; carefully drain the juice from the sediment, and run it through several thicknesses of clean flannel, if no other filter be available. After this, fill into clean bottles. Do not fill entirely, but leave room for the liquid to expand when again heated. Fit a thin board over the bottom of an ordinary wash boiler, set the filled bottles (ordinary glass fruit jars are just as good) in it, fill in with water around the bottles to about an inch from the top of them, and gradually heat until it is about to simmer. Then take the bottles out and cork or seal immediately. It is a good idea to take the further precaution of sealing the corks over with sealing wax, to prevent mold germs from entering through the corks. Should it be desired to make a red juice, heat the crushed grapes to not above 200° F., strain through a clean cloth, set away to cool and settle, and proceed the same as with light-colored juice. Many people do not

even go to the trouble of letting the juice settle after straining it, but reheat and seal it up immediately, simply setting the vessels away in a cool place in an upright position, where they will be undisturbed and the juice allowed to settle, and when wanted for use the clear juice is simply taken off the sediment. Any person familiar with the process of canning fruit can also preserve grape juice, for the principles involved are identical.

Must is a valuable product, and many pleasures and comforts may be derived from its use. It contains a large part of the valuable ingredients of both fresh and canned grapes, and can be used in many more ways and for many more purposes.

## USES OF UNFERMENTED MUST.

The uses of unfermented must are many. It is used in sickness, convalescence, and good health; as a preventive, as well as a cure. By the young, by persons in the prime of life, and by those in old age it is used at all seasons of the year, whether that season be warm or cold, wet or dry. It is used in churches for sacramental purposes; at soda fountains as a cool and refreshing drink; in homes, at hotels, and at restaurants as a food, as a beverage, as a desert, and in many other ways. When people become accustomed to it they rarely give it up; hence the manufacture of grape juice will probably increase enormously as the years go by.

Dr. Miradow Minas, at Jurjew (Dorpat), experimented on himself with pasteurized must during fifty-three days, dividing the time into thirteen periods. He took the following daily rations of food: Water, 2,100 cubic centimeters; meat, 3,000 grams; tea, 9 grams; meat extract, 5 grams; light bread, 500 grams; sugar, 85.38 grams. During the first two and the last two periods he took no must. In the third period he took 300 cubic centimeters daily; in the fourth, 600 cubic centimeters, and thus gradually increased the portion until 1,250 cubic centimeters in the seventh period, which lasted five days, were taken. After this he gradually decreased the portion until 250 cubic centimeters were used in the eleventh period.

The conclusions reached were:

Through the rational addition of pasteurized must to a satisfactory mixed diet the cleavage of protein in the body is diminished. The power to protect protein is due to the grape sugar present, and is dependent not alone upon the quantity of grape juice taken, but also upon the kind and amount of protein consumed. The richer the food in easily digested protein the greater the power of the grape juice to protect protein. With an abundant diet the more or less long continued use of pasteurized must tends to induce a gain in body weight. The material gained may consist of nitrogenous substance or fatty tissue. When 300 to 750 c. c. of pasteurized grape juice is consumed daily the resorption of nitrogenous material is increased. When larger quantities are consumed (1,000 to1,250 c. c.) the resorption of nitrogen diminishes somewhat, but in all cases it is better than on the same diet without the addition of pasteurized grape juice. The consumption of 300 to 500 c. c. of unfermented grape

must daily diminishes intestinal fermentation. Larger quantities are either without effect on the intensity of intestinal fermentation or by diminishing the resorption of nitrogen increase the amount of ether sulphates excreted in the urine.

It should be said in considering the results obtained by Minas, that practically the same favorable results attributed to the use of grape juice have been found to follow the consumption of cane sugar. It therefore seems not unlikely that the value of grape juice as a food depends chiefly on the sugars present, though it should be remembered that the agreeable flavor undoubtedly increases the appetite and very probably increases the flow of digestive juices. Furthermore, grape juice offers the sugars in a reasonably dilute as well as a palatable form.

## A FEW GOOD RECIPES.

### GRAPE NECTAR.

Take the juice of two lemons and one orange, one pint of grape juice, one small cup of sugar, and a pint of water. Serve ice cold. If served from punch bowl, sliced lemon and orange add to appearance.

### AN INVALID DRINK.

Put in the bottom of a wineglass two tablespoonfuls of grape juice; add to this the beaten white of one egg and a little chopped ice; sprinkle sugar over top and serve. This is often served in sanitariums.

### GRAPE PUNCH.

Boil together one pound of sugar and half pint of water until it spins a thread; take from the fire and when cool add the juice of six lemons and a quart of grape juice. Stand aside overnight. Serve with plain water, apollinaris, or soda water.

### GRAPE SHERBET.

For eight persons, mix one pint of grape must, juice of lemon, and one heaping teaspoonful of gelatin, dissolved in boiling water; freeze quickly; add beaten white of one egg just before finish.

### GRAPE ICE CREAM.

One quart of must, one quart of cream, one pound of sugar, and the juice of one lemon.

### SYLLABUB.

One quart of fresh cream, whites of four eggs, one glass of grape must, two small cups of powdered sugar; whip half the sugar with the cream, the balance with the eggs; mix well; add grape juice and pour over sweetened strawberries and pineapple or oranges and bananas. Serve cold.

BOHEMIAN CREAM.

One pint thick cream, one pint grape-juice jelly; stir together; put in cups and set on ice. Serve with lady fingers.

Besides the recipes just given, many more are enumerated by the manufacturers, such as grape ice, grape lemonade, grape water ice, grape juice and egg, baked bananas, snow pudding, grape gelatin, junket and grape jelly, tutti frutti jelly, grape float, grape jelly, grape juice plain, grape soda water, and scores of others.

## ANALYSES OF GRAPE MUST.

The analyses of a California must, as published in Bulletin No. 130 of the California Experiment Station, and of Concord grape must analyzed by Mr. L. S. Munson, of the Bureau of Chemistry, U. S. Department of Agriculture, are appended herewith, and may be of interest:

| | Concord. | California. |
|---|---|---|
| | *Per cent.* | *Per cent.* |
| Solid contents | 20.37 | 20.60 |
| Alcohol | None. | None. |
| Total acids (as tartaric) | .663 | .53 |
| Volatile acid | .023 | 03 |
| Grape sugar | 18.54 | 19.15 |
| Free tartaric acid | .025 | .07 |
| Ash | .255 | .19 |
| Phosphoric acid | .027 | .04 |
| Cream of tartar | .55 | .59 |

The comparison between the two becomes all the more interesting from the fact that California musts are made from Vinifera, or the European grapes, whereas the commercial musts of the Eastern States are made almost exclusively from the Concord, a Labrusca, or American variety.

## PRICES AND STATISTICS.

The average prices to consumers are as follows:

| | Per case. |
|---|---|
| Cases of 1 dozen quart bottles | $4.50 to $6.00 |
| Cases of 2 dozen pint bottles | 4.75 to 6.25 |
| Cases of 4 gallon bottles | 5.00 to 6.00 |

One firm in 1901 used, in their manufacture, 8,000 gross of bottles. To fill these required 1,000 tons of grapes, 8,000 gross of corks, 1,100,000 caps, as many labels and wrappers, and 60,000 boxes. In the Chautauqua district alone about 300,000 gallons of unfermented must was made in 1901, and all those engaged in its manufacture are enlarging their plants.

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## BULLETINS OF THE BUREAU OF PLANT INDUSTRY.

The Bureau of Plant Industry, which was organized July 1, 1901, includes Vegetable Pathological and Physiological Investigations, Botanical Investigations and Experiments, Grass and Forage Plant Investigations, Pomological Investigations, and Gardens and Grounds, all of which were formerly separate Divisions, and also Seed and Plant Introduction and Distribution, the Arlington Experimental Farm, and Tea Investigations and Experiments.

Beginning with the date of organization of the Bureau, the independent series of bulletins of the several Divisions were discontinued, and all are now published as one series of the Bureau.

The bulletins issued in the present series are:

No. 1. The Relation of Lime and Magnesia to Plant Growth. 1901.
2. Spermatogenesis and Fecundation of Zamia. 1901.
3. Macaroni Wheats. 1901.
4. Range Improvement in Arizona. 1901.
5. Seeds and Plants Imported through the Section of Seed and Plant Introduction. Inventory No. 9, Nos. 4351–5500. 1902.
6. A List of American Varieties of Peppers. 1902.
7. The Algerian Durum Wheats: A Classified List, with Descriptions. 1902.
8. A Collection of Economic and other Fungi Prepared for Distribution. 1902.
9. North American Species of Spartina. 1902.
10. Records of Seed Distribution and Cooperative Experiments with Grasses and Forage Plants. 1902.
11. Johnson Grass: Reports of Investigations made during 1901–1902. 1902.
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16. A Preliminary Study of the Germination of the Spores of Agaricus Campestris and other Basidiomycetous Fungi. 1902.
17. Some Diseases of the Cowpea. 1902.
18. Observations on the Mosaic Disease of Tobacco. 1902.
19. Kentucky Bluegrass Seed: Harvesting, Curing, and Cleaning. 1902.
20. Manufacture of Semolina and Macaroni. 1902.
21. List of American Varieties of Vegetables. 1902. [In press.]
22. Injurious Effects of Premature Pollination. 1902.
23. Berseem: The Great Forage and Soiling Crop of the Nile Valley. 1902.